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DEVELOPMENT OF AN INCREASED SAMPLING RATE MONITORING SYSTEM

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ABSTRACT

This report briefly describes a developmental device that samples air for small particles in clean rooms; it differs from standard monitors in that it samples at an increased rate and is designed for very low concentrations of airborne particles. Test results, also included in this report, indicate that this device is superior to present particle counters.

Author

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Introduction

A need has recently arisen for airborne-particle counters that are much more sensitive to low particle concentrations than present counters. The best available counters at present are not reliable for airborne-particle monitoring below 1000 particles/cu. ft. without extensive testing; this deficiency is due chiefly to their low sampling rate, approximately 0.01 cu. ft./min. For example, such an instrument monitoring a Class 100 clean room would average one count per minute with a multiplier of 100 to convert to cu. ft./min. if 100 particles/cu. ft. were present in the air (this is the maximum number of particles/cu. ft. in a Class 100 room). Since conditions in any operational clean room change very rapidly, the available monitors should be considered only as crude indicators for Class 100 clean rooms.

Approach to Problem

The most obvious approach to this problem is the development of equipment that will sample air at much higher rates. Present monitors (light scattering particle counters) are not adaptable to modification for higher air flow rates since the illuminated sensing zones are too small to permit larger air columns to flow through them.

The development of an optical system to provide a larger sensing zone appears to present no great problem. Present design techniques will more than likely be adequate. A design goal for sampling rates should be not less than 1 cu. ft. air/min. and up to 10 cu. ft./min.

Forward light scattering principles should be considered in preference to presently used 90-degree scattering. This should provide better sensitivity as well as allow much lower background noise levels.

A prototype monitoring device was designed and constructed at Sandia which samples at the rate of 1 cu. ft./min. An optics system from a Sinclair-Phoenix Photometer Model JM-2000 was used with a two-stage pulse amplifier. The output of the amplifier was fed into a standard pulse counter. The system was calibrated to count all particles of 0.5 micron size and larger. Accurate particle sizing was not possible since the light uniformity of the optics system was inadequate. However, good correlation with the Royco PC-200A was achieved when the system was used for total particle counting.

This device was used during evaluation tests to:

1. Monitor a laminar flow clean room.
2. Count particulate material generated by individual clean-room workers.
3. Check the HEPA (high efficiency particulate air) filters for leaks.

Results of Tests

Monitoring a Laminar Flow Clean Room

The experimental device was found to be useful for measuring clean room recovery time as well as general clean room monitoring. Since the sampling rate was 1 cu. ft./min., no conversion factor was necessary for 1-minute counts to convert the count to particles/cu. ft.

Calibration was accomplished by using a laminar flow clean room to reduce the particles count to approximately 1000 particles/cu. ft. Normal distribution of particle sizes was obtained by introducing air from the general laboratory area. The count of the experimental counter was then adjusted to match that of the Royco PC-200A. It was immediately apparent that repeatability of the experimental device was much better than that of the Royco. In a series of 15 tests, data varied no more than 20 counts out of 1000 particles/ cu. ft.

Higher concentrations were sampled up to 10, 000 particles/cu. ft. At approximately 4000 particles/cu. ft. the experimental counter suffered loss due to particle coincidence in the sensing zone of the counter. At concentrations above 6000 counts/cu. ft., the loss was so severe that the results were unreliable.

Concentrations below 1000 particles/cu. ft. were sampled by both counters. The experimental counter showed good repeatability to almost zero count conditions, whereas the Royco counts were increasingly erratic as the concentrations were decreased and were unreliable below 500 particles/cu. ft.

Clean room recovery tests were easily made with this device. Near zero counts were obtained in less than 15 seconds after clean room turn-on, with an occasional count which appeared to be from the interior of the sampling tube walls and from the HEPA filter protective screen, particularly after a clean room shutdown period.

HEPA Filter Leak Test

The experimental sampler was used to scan HEPA filters using the same procedures as used for the Sinclair-Phoenix photometer. An audio amplifier and speaker were connected to the sampler to provide audible indications of particle counts.

Results of Test -- Scan rate and response were approximately the same for the standard Sinclair-Phoenix photometer (Model JM-2000).

Sensitivity was improved for very small leaks in that single particles were indicated, whereas the photometer gave mass readings.

The audio response provided an indication to the operator, obviating the necessity for constant visual observation of a meter or counter.

Work Location Monitoring Tests

A typical work location was set up in a laminar down-flow clean room. A trained clean-room worker was seated at the work location assembling small components. The worker was clothed with head covering, a knee-length smock, and carefully cleaned rubber gloves. The high rate sampler probe was placed, in turn, at five locations about the critical work zone as described below.

Test 1. The probe was positioned approximately midway between the critical work and the worker and 2 inches above the work bench surface.

Results: Counts varied from 82 to 145 counts/cu. ft. and averaged 111 counts for 20 one-minute periods. The device showed excellent response to the worker's movements.

Test 2. Probe location was 6 inches to one side of critical work and 2 inches above work surface.

Results: A range of 10 to 50 counts/cu. ft. was obtained in this position, averaging 32 counts/cu. ft. for 15 tests. Counts were obtained in this position only when the worker's hand or arm passed over the probe.

Test 3. Probe location was 8 inches directly above critical work.

Results: Less than one count per cubic foot of air. Counts taken in this position were approximately the same as ambient room conditions.

Test 4. The probe was positioned to almost touch critical work (toward worker), approximately 2 inches above work bench. The probe was below the worker's hands during much of the testing time.

Results: Counts averaged 48 counts/cu. ft. for 20 tests with a range of 8 to 80 counts.

Test 5. The probe was located 26 inches above the floor and just below the bottom of the worker's smock.

Results: An average of 208 counts/cu. ft. and a range of 98 to 310 counts were found in this position for 20 tests. The counter was found to respond directly to the worker's activity.

Conclusions

The successful operation of this experimental device indicates that:

1. Increased sampling rates of particle counters will provide an improved means of monitoring very clean environments.
2. Work location monitoring is made practical.
3. A single instrument may be used for clean room monitoring and leak testing of HEPA filters.
4. Air sampling rates can be increased to at least 1 cubic ft./min. and possibly up to 5 cu. ft./min.

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